

THE
Journal
OF
Nervous and Mental Disease.

AMERICAN NEUROLOGICAL ASSOCIATION.

*Twenty-first Annual Meeting, held in Boston, June 5, 6
and 7, 1895.*

(Continued.)

Dr. CHARLES K. MILLS opened a discussion on the subject of

CORTICAL LOCALIZATION IN THE LIGHT OF
RECENT RESEARCHES INTO THE MINUTE
ANATOMY OF THE CORTEX.

He said that the different theories as to the separate cortical localization of movements and of cutaneous and muscular sensation, which had been the subjects of so much controversy, have again become prominent in the light of the researches founded upon the methods of Golgi, and particularly of those made by Ramon y Cajal, Von Gehuchten, Schäfer, Andriezen, and others. Those who contend against the doctrine that the Rolandic cortex is a purely motor region, believe that they have received additional support for their views. The varying hypotheses with reference to the functions of the cortex were reviewed. Dr. Mills held that, as shown by Forel and Nansen, we have been too long handicapped by prevailing ideas of cell-action and by theories of the parts played by the cell-bodies as originating centres. Impulses are transmitted and transferred by processes as well as by cell-bodies, and the function of the latter is chiefly trophic. The new researches and theories, he

believed, did not compel abandonment of former views as to special localizations, although different standpoints might in some instances need to be taken. Disregarding theory entirely, he believed that the subdivision of the cerebrum into physiologic lobes—higher psychic, motor, sensory (meaning for the representation of cutaneous and muscular sensations), visual, auditory, olfactory, gustatory, and naming—remained for the practical purposes of the physician and surgeon the best. While the whole of the cortex in some of its strata may be regarded as a sensory expanse, the Rolandic portions and particularly the convolutions cephalad of the central fissure, constitute a region that is related to specialized movements of various parts of the body. One calls it motor, another kinesthetic, another sensorimotor, and another executive; but for the purposes of the physician and surgeon it is a motor sphere, the irritation of which causes specialized movements, while its destruction impairs or abolishes these movements. He did not believe with Andriezen that it is necessary to regard the ambiguous and great pyramidal cells of this region, whose apical processes received the terminals of the fillet-radiations, as the first sensory cells of the cortex. Indeed, he regarded it as important to rid ourselves entirely of the idea of sensory cells and motor cells. The cortex contains localized areas. To abandon separate sensory and motor localization would, he believed, necessitate the abandonment of visual, auditory, gustatory, and other subdivisions of the cortex. The cerebral sensory area—that is, the area of representation for skin-sensations and muscle-sensations,—from his point of view, would be that part of the cerebrum where the fillet-radiations in their most compact forms are nearest to the surface of the brain, and therefore this region might continue to be described, as it had been by him, as in the postero-parietal, quadrate, and fornicate convolutions. Destruction of this region, especially if bilateral, caused more or less impairment of sensation. He referred to cases as confirming this view. In the cerebrum, as in the spinal cord, were fields of conjunction between so-called cortical areas, and lesions of these fields of conjunction or at the terminations of the sensory projection-fibres might give rise to temporary sensory disturbances, but these were persistent only when the lesions involved the convolutions included by him in the general sensory area.

DISCUSSION.

Dr. DANA.—Dr. Mills and I have discussed these questions several times before, and I don't suppose we shall be likely to change our views very much. The doctor has gone over a list of authorities who hold different views as to the relations of the sensory and motor functions of the cortex, and has referred to some advances in anatomy; but, it seems to me, he has not referred to or tried to explain the facts which establish the proposition that I hold regarding this subject. Two or three months ago I went over it again. I collected a large number of other cases and added some of my own, all supporting my view; and it is because I cannot explain the clinical facts or the pathological facts by any other hypothesis than by supposing that the motor and sensory functions are practically united that I still hold to that view. Dr. Mills gives a very learned discussion about the nerve cells and some theories about their relations, but if he will explain to me how it is when I cut away a section of the mid-central or pre-central convolution and find tactile anæsthesia and muscular anæsthesia the next day with paralysis, if he will explain that on any theory except that these two functions are united in that spot, I should like to have him do it. Those cases have become so numerous that it is not fair to get up and talk about this subject without referring to it. Why doesn't he explain those cases, and then we will try and accept his theory if he can adjust that fact. Such cases I have had, and so have Drs. Knapp and Putnam. They are extremely numerous in the literature of neurology now. If you carefully shave off the anterior, pre-central convolution in this middle part, you will get sensory disturbances, anæsthesias.

Again, Dr. Mills perhaps may not be aware that in the living subject, two persons, an English physician, Dr. Russell, and myself have directly irritated the motor cortex, also in front of the fissure of Rolando and produced sensory disturbance associated with motor. Now, if a man's sensory functions are located in the gyrus fornicatus, I do not understand how the passage of the electric current applied to the arm-cells should cause sensations entirely analogous in the arm to those of a tactile impression made upon the skin. In fact, the whole weight of clinical evidence is in favor of motor sensory union, the surgical operations, the tumors, the

softenings, the laboratory experiments all furnish facts which cannot be explained on any other hypothesis, so far as I know, than that the two functions are essentially identical anatomically.

Dr. Mills has a sort of argument from analogy. He says the other special centres, the centre for visual sensations and for auditory and gustatory sensations are separate from the motor centres, and that therefore cutaneous and muscular sensations would naturally have centres separate from the motor areas. I admit that that is a plausible theory, but it does not at all hold against any actual facts, and when we come to analyze it, it is not plausible after all. The visual sensations are not so closely related to motions as are the cutaneous and muscular sensations. We have got to have for the performance of co-ordinated movement a very close anatomical relationship between the muscular and cutaneous sensations. We cannot afford to have muscular sensations impinge on the gyrus fornicatus and have associating fibres then conduct these semi-impulses to the central convolutions. They must be close together anatomically for the purposes of a perfect machine, otherwise we could not make rapid motions; and I believe it is for that reason that nature has gradually shifted the sensory receptive cells, so that they are in approximately close relation with the motor cells.

I believe that perhaps if we were all agreed as to exactly what is meant by sensations and exactly what tests we use for making sensations, and were agreed about the terminology of our discussions, we would not have perhaps so much discussion about this matter. It may be we are not so far apart after all. I quite agree with Dr. Mills that sensations are not closely localized, and I agree that we should speak of sensory areas, but I do not believe we have sensory areas separate from the motor ones back in the post-central and parietal lobes or in the gyrus fornicatus. I do not accept Dr. Starr's view, that the sensory centres are back of the fissure of Rolando, for from the evidence I have been able to collect, there is just as much proof that the pre-central convolution has sensory functions as that the post central one has.

Dr. PUTNAM.—One or two things only I should like to say. In the first place, I think Dr. Dana's closing sentence must be accepted as absolutely certain, that the convolutions in advance of the fissure of Rolando, the

function of which we ordinarily associate with localized movements, have also to do with sensation. In support of that fact I may mention one case, among many, where Dr. Warren excised a minute piece of the cortex in a young man with epilepsy beginning in one hand,—a piece a few millimetres in diameter,—with the result of producing paresis of the hand, paralysis in the beginning, and also a disturbance of the sensibility of the whole hand, which, however, soon passed away. It seems to me that shows that in some way the function of sensibility is closely related to the same centres that represents the function of motion. What that relationship, is it seems to me, is a matter still calling for a good deal of study. My own view of the difficulty is that we are still decidedly lacking in a sufficiently adequate physiological or psychological conception of what we mean by those various terms. My own view is that the function of sensibility must be very widely distributed. When any part of the body is touched or any motion takes place there, various other functions are immediately incited to action. A motion of the eyes must follow very rapidly on a sensation, because the individual touched must immediately know from what cause the touch arises, and the like; so that the close relationships must be established, and as a matter of fact, we have every reason to think they are established, with all sorts of cerebral functions of various kinds. Another thing which is interesting, I think, is that when we apply a sensory stimulus we are applying what may perhaps be a very gross molecular disturbance of a nerve at the part touched. This then impinges on some part of the brain primarily, and from there it must spread widely, and passing through some secondary channel if its natural channel is obstructed. It is instructive to remember that a sensation will make its way from a minute portion of the substance of the spinal cord that is left, so in the case of the brain, if one channel is cut off it will make its way into a dozen other channels. A case illustrating that occurred at the Massachusetts Hospital. Dr. Richardson has recently operated on a patient I saw first in consultation outside with the result of eventually removing by a second operation an enormous tumor larger than an orange, which lay directly in the motor tract. The patient had been paralyzed for some time, and it would certainly be that the whole of the motor area had been destroyed by the growth with a good part

of the internal capsule. Nevertheless that patient still has a very considerable degree of sensation left, though, of course, modified. Contact gives rise to a painful distressing feeling, but pricking and even a slight rubbing is felt and the localization is still fairly good, although contrary to what Mr. Horsley says, he localizes not nearer the root of the limb where the contact is made, but farther from it, towards the extremity of the limb; nevertheless he feels in a very high degree, so that although the removal of the motor convolution has affected the sensibility of the limb it has not by any manner of means destroyed it, and that it seems to me is a thing we have got to bear in mind. We know nerves will stand a high degree of injury sufficient to entirely destroy their motor functions without interfering materially with their sensory functions. The same thing in the cord; a minute portion of it will convey centripetal impressions. Sensibility would seem to be rather peculiar in the fact that it is almost always related to something else. A sensation is felt almost always for the sake of something else.

I would like to say in addition that I have in mind one or two cases where the sensory functions have been disturbed in connection with paresis of one hand, and where it seems to me that I could detect a higher degree of impairment of sensibility on the side of the ulnar part of the hand than on the side of the median portion.

Dr. STARR.—I think that it is our business, if possible, to bring together all the various facts that come into our knowledge in regard to this question. Now, we certainly have facts that Dr. Dana has stated that are indisputable, and those of us who are constantly seeing cases of cerebral surgery and exsecting cysts and portions of the cortex, small in extent, or who are seeing pressure produced upon the cortex by clots that can be removed, are perfectly positive that a lesion of a small limited area of the so-called motor zone does inevitably produce in almost every case more or less disturbance of sensation. I do not hesitate to say that I consider that I was completely mistaken in 1890, when I maintained that sensations were received only behind the fissure of Rolando. I believe with Dr. Dana to-day that there are disturbances of sensations produced by small lesions anterior to the fissure of Rolando, and that the sensory area of body corresponds exactly with the motor area of the body so far as we can determine clinically. I cannot shut my

eyes to the facts that have been brought out time and again right before me on the operating table, and subsequently to it, and I do not hold to theoretical explanations when in contrast to the facts we can put our fingers on definitely, but I think it would be a mistake to draw too broad a conclusion from these facts. That is one set of facts we have got to regard.

Secondly, when you come to analyze the embryology of the brain, it seems to me that another set of facts confront us. The recent address of Flechsig throws a great deal of light upon this subject. You probably all have read his address translated in the *British Medical Journal*, April, 1895. Flechsig showed conclusively that in the course of development there are two distinct and separate periods of development to be traced in the embryo in the cortex: the first period in which there are formed projection tracts of different kind, the so-called motor tracts; and sensory tracts of distinct kind, visual, auditory and olfactory, and also tactile, the latter are distinct and separate from the motor and they terminate in areas of the brain separate from the motor and posterior to the fissure of Rolando. That is the second set of facts. We cannot get away from these facts of Flechsig. He shows that the second stage of the development of the cortex is an enormous development of association fibres, separate and distinct in the life of the child because it is only when these fibres begin to develop that evidence of the combination of the various sensory memories are shown in conscious intellectual acts. That is the second set of facts, and I think the true solution of these apparently contradictory facts is indicated by Dr. Putnam in his phrase, which I like very much, the diffusion of sensations, and I think that there we have the explanation of the whole problem. We know from Cajal and Golgi methods of staining that the sensory fibres, when they come in, do not terminate in a distinct sensory cell. And I think we must give up our ideas of sensory cells as such. When you think of the innumerable sensations that come from the distinct touch as of a cigar on the finger, the reflexes it occasions, the reflex withdrawal of the finger, the vasomotor reflexes and the automatic acts, such as catching one's breath, and then, lastly, the reception of these conscious sensations in the cortex, I think it perfectly evident that that term diffusion of sensibility is a capital one, and I think our present anatomy shows why it is; it is because these sensory fibres terminate in

brush-like expansions, so that we must conceive of a sensory fibre as virtually terminating in a long region of the nervous system, in fact, almost throughout its entire length. Now suppose that with the continued passage of sensations over these fibres diffusing themselves in general directions habit opens the way in one direction rather than in another, that a sensation coming in might be diffused from the arm over the entire parietal arm centre and also diffused over the motor centre, but inasmuch as we guide our movements by touch habitually, the result that a greater passage is opened out over to the motor zone, and therefore sensations reach the motor zone before and more rapidly than they reach the real sensory zone, and they are received there just as decidedly as they are elsewhere. I think that diffusion of the sensibility in various areas gives an explanation for the fact that a few cases are on record where we get sensations lost alone, and the vast majority of cases show that sensation and motion are lost together. The sensations go in different directions, but habit produces the effect of sending them chiefly to the motor area, and therefore they are received there as well as elsewhere. From Flechsig's researches I think we must abandon the idea of consciousness and conscious perception, and perhaps to some extent of conscious motion being associated with particular cells. It seems to me it is just as reasonable to believe it is associated with association fibre action, the combined activity of various areas of the brain, as it is with single cells, and I think we will come down finally to the fact that a cell is to be regarded more as a trophic centre than as a motor or sensory cell.

Dr. DERCUM.—I am glad to see the stand that has been taken—so different from what was taken a few years ago with regard to cerebral localization. It enables us to explain certain other phenomena not alluded to here, namely, such facts as that the fact that the cuneus fails to atrophy in cases of blindness lasting for many years. Certain it is that we have no right to conclude that the cuneus is related to no other function than that of vision. It is probable it does many other things. To my mind the various centres of the cortex, as we know them clinically and pathologically, are simply highways of ingress and egress to the general cortex. The facts give us no right to say that this portion of the brain does only this special thing and that portion only that special thing. A so-called sensory centre is merely a

point at which a stimulus reaches the cortex, and from which it is diffused through neighboring and perhaps distant areas. General biological considerations also would negative the sharp differentiation of cells into special functions. Nerve protoplasm reacts to certain forces ; to say that one cell reacts to one mode of motion, and another to another, is to my mind unphilosophical and not borne out by general biological considerations.

Dr. RICHARDSON.—I have nothing special to say except that I have been extremely interested in this discussion, although I know very little about the subject except from the clinical standpoint. I would like to say with reference to the tumor which Dr. Putnam spoke of, that so far as I know, there was no destruction of the motor areas except by pressure of the growth. The tumor was very large, more than filled a pint-jar ; the pathologist thought it would weigh more than a pound, so that it took up a very large portion of the left hemisphere. During the operation I touched the falx throughout a great deal of its extent, my finger passing through the very large opening through the crista galli to the tentorium. But so far as I know, there was no destruction of brain tissue by manipulation during the operation. The man is now doing very well.

Dr. JOSEPH COLLINS.—I have recently had a case of cerebral surgery in which development of sensory and motor defects have been rather peculiar, and I would like to ask if any one of the members had seen such an occurrence. A young man had his first attack of Jacksonian epilepsy in November, and the movements were contraction of the finger and thumb. When I saw him in March he had had three attacks, only one of which had been associated with loss of consciousness. At the advice of Dr. Sachs and myself, Dr. Gerster operated on the patient, making the opening over the superficial cortical thumb and index-finger centre. It was with a great deal of difficulty that we got through the skull. The patient bore the anæsthetic very badly, and we had to postpone the operation after the skull had been opened, that is, we had to postpone opening the membranes and excising some of the cortex. That night the patient had an extremely severe attack which had been preceded a short time by the development of very high temperature. The attack was accompanied by loss of consciousness for a long time. The following morning he had paresis of the right upper extremity and loss of sensa-

tion, that is, loss of tactile sense, loss of sense position and loss of muscular sense in the right hand. Three or four days afterwards we opened the dressings and found a good deal distention of, and effusion into the surrounding cellular tissue, but otherwise where the operation had been done, it seemed very much like normal. Then Dr. Gerster opened the dura, and cut out a large part of the cortex, and incidentally I might say, we found an old pachymeningitis there, and the Nissl stain revealed degeneration of the cortical cell. We put him back to bed, and tested his hand for sensibility that evening, and found that the disturbances of sensation had all disappeared, every one of them. Now, it seems to me that that opens up an avenue that has not been recognized, insomuch as the disturbances of sensation came on before the cortex had been excised and disappeared almost immediately after excision of the cortex. If we put the localization of sensation and motion one over the other, superimposed in the paracentral convolutions, this experience seems to indicate that they are not intimately blended, because when we excise the motor cells the sensory anæsthesia disappears at once, while the paresis remains.

Dr. ANGEL, of Rochester.—I can corroborate Dr. Collins because I had a similar case. I made the prediction that there would be paralysis for five or six days at least, and to my surprise when the boy recovered from ether two or three hours after operation, I tested him thoroughly and found sensory paralysis. Within twenty-four hours there was absolutely no sensory paralysis or sensory disturbance. It seems to me that that is the characteristic distinction between sensory disturbance from removal of the cortex anterior to the fissure of Rolando and posterior to the fissure of Rolando. I think you will get a deeper and more prolonged disturbance of sensation posteriorly than anteriorly. It seems to me that must be explained possibly through the association tracts. I do not believe it is possible to make an impression upon any centre of the brain closely related to another centre without affecting temporarily that sensory centre. Whether this will explain the reason why we have a short paralysis of sensation when we remove the motor cortex or not is, of course, beyond our power yet to determine. It may be by cutting into the cortex that we affected the rootlets of the radicals from the sensory tract which we suppose reach over and produce this diffusion of sensation that has been referred to.

Dr. PRINCE.—I would like to say one or two words only on this subject. It is one in which I have followed the evidence for a long while with care. I agree entirely with Dr. Starr, that we must take into consideration the facts, but they must be all the facts and not an expurgated edition. Any theory to be acceptable must explain all known facts and not skip those that inconveniently present themselves for examination. Now Dr. Starr has insisted upon two sets of facts, namely, one set, that following operation on the motor cortex you frequently get some loss or disturbance of sensation; but I wish to call Dr. Starr's attention to the logical fact, that it is an inference from the clinical fact and not the fact itself that these portions of the cortex are the centres of sensation. This inference is of value only so far as it explains all the other facts. The other fact to which he has called attention—the distribution of the fibres is an interesting one and of value as evidence. But there is a third fact which Dr. Starr has left out of consideration, and that is the fact that in many cases which have been referred to by other gentlemen present, there has been no loss of sensation. These cases have been numerous. If I remember correctly the figures of a large number collected by Charcot in which the presence or absence of anæsthesia was noted, in a majority no loss of sensation was present. Some will say that these cases were imperfectly observed. Well, then, suppose that only a minority presented no sensory loss. Those who have read Darwin's autobiography—a book which everyone enjoyed in scientific research should read—will remember that Darwin in a certain passage attributes his success largely to having always recorded the exceptional cases, those that did not follow the general rule. He thus was enabled to formulate a general law to which all cases would be subject. If we are to draw correct inferences from the facts as to the localization of sensation, the minority of cases must be explained. Several cases have just been mentioned in this discussion, where excision of a portion of the Rolandic cortex has not been followed by sensory loss. A great many could be mentioned. As I have said, I believe that the majority of such cases do not exhibit sensory loss, but I assume it to be the other way. I wish to refer now to two cases which are of great value as evidence. Many gentlemen will remember the case of Dr. Hale White, published in 1893, in which case a portion of the motor cortex was excised, and the sen-

sation over the corresponding part of the body afterwards tested with great care with the only purpose of determining the relation of sensation to the motor cortex. Although paralysis followed there was not loss of sensation.

But what seems to me a clinical test is a case published lately by Beevor and Ballam, *British Medical Journal*, January 5, 1895. In this case it will be remembered that a piece of brain in the Rolandic area was scooped out, equal in size to "half an orange," as described in the report. A hole two inches in depth was made involving a large portion of the ascending convolutions, the quadrate lobule, and a portion of the adjoining parietal convolution. Before the operation there was hemianæsthesia with paralysis. After recovering from the operation there was persistence of paralysis, but there was absolutely no loss of sensation whatsoever, although the most minute and careful tests were made. A case like this seems to me a clinical one. If so large a portion of the motor cortex can be destroyed without resulting loss of sensation, I am unable to understand how this portion of the cortex can be spoken of as a sensory centre. I admit there is a good deal of ambiguity about the meaning of the word "centre." But for practical purposes and within the meaning of the discussion we must mean a place in the cortex, the destruction of which abolishes certain functions. Now these cases, cases like the ones I have cited—and they are numerous—must be taken into consideration. They cannot be bound over as disagreeable cases which we don't want to hear. They may be unpleasant but they are true. Dr. Dana asks how, then, are we to explain the other group of cases, in which loss of sensation does follow lesions of the Rolandic cortex. That is another question. We may answer that we don't know how to explain them. But because you can't find a satisfactory explanation you have no right to draw inference which are illogical, and leave out of consideration a large group of contradicting facts.

If asked to present a theory, I think I could offer several that would satisfy the conditions, although I have no proof of the correctness of anyone. What is needed is evidence. Here is an explanation which is not impossible.

We know very well that we may have an injury in other parts of the brain, followed by disturbance of function which we know is not localized in that part; for

example, it is common to have injury of the corpus striatum with aphasia and sensory disturbances; even temporary hemianopsia is common with lesions of the corpus striatum, and yet I don't suppose any one localizes the visual centre in the corpus striatum. Aphasia is common as a secondary disturbance with lesions in different parts of the brain, and yet we know that motor aphasia depends upon a specially localized lesion. We, therefore, must regard such phenomena as secondary disturbances. In the case of the corpus striatum we can explain the symptoms by presence of oedema or local congestion of the internal capsule. It is possible that such secondary symptoms may sometimes be explained by some form of irritation of associated fibres or the effect of inhibition.

The observation of Head have placed the symptomatic effect of reflex irritation upon a new basis, and offer a new field for research. But whatever the explanation, we must not hastily accept inadequate theories simply to cover up a hiatus in our knowledge.

Dr. PUTNAM.—I wish to reinforce what both of the last speakers have said. We have in the relation of motor and sensory aphasia a very pregnant example of what has been referred to. No one would speak clinically or anatomically of the sense of hearing and comprehension of spoken words as located in the same part of the brain, but we know these two functions lean to one another internally so closely that not only we get more or less aphasia from disturbance of the centre for hearing, but we also get (to a less degree) disturbance of comprehension in most forms of motor aphasia; in short, cerebral functions do not exist for themselves, they exist as related to other functions, and you cannot destroy one without more or less impairing others, although it may be only for a brief time.

The CHAIRMAN.—When Dr. Mills wrote to me the question of recanting his heresies, he asked me to take part in the discussion. I have very little to add to what has been said. It seems to me that the whole of our knowledge of the neuron goes to show the very pronounced dependence of the motor neuron upon the sensory neuron. In the primary neurons it has been clearly proven that the terminal processes of the axis cylinder of the sensory neuron are closely connected with the apical processes of the motor neuron in the cord. Golgi in his earlier work held clearly that we cannot make a

distinction in the cortex from its minute anatomy as to what portion of it was sensory and what portion of it was motor; in other words, that the cells which he said at that time were motor were to be found in the areas of the cortex distinctly called sensory, that the cells considered as sensory were to be found in the area of the cortex which he considered motor. That, of course, is not to be accepted without more or less question; but we do know this, that the recent studies in the development of the fibres in the brain itself, show that the sensory tract passes distinctly upwards toward the central convolutions, the parietal region, rather than downwards and inwards toward the gyrus fornicatus, where Ferrier sometime ago located the sensory centres, and where Dr. Mills, I think, still has a leaning toward placing it. In other words, judging from all the analogies in the anatomy of the brain, the higher sensory neurons must either pass upward directly to connect by their axis cylinder processes with the cell bodies of the motor neurons, or there must be association tracts from these axis cylinders going up to the motor neurons. Now we find no association tract passing up from the gyrus fornicatus to the central fissures, and furthermore, although Dr. Prince has just brought up the negative cases of lesion of the central convolution with injury to sensation, there have been in the past, as Dr. Prince will certainly remember, a very large number of so-called negative cases about the central convolution with absolutely no motor disturbances. Most of those with our increasing knowledge have been explained away, and ten negative cases do not, it seems to me, afford as much evidence as one positive case. The positive cases of sensory disturbances following lesions behind and in front of the fissure of Rolando are increasing in number and become, as it seems to me, very conclusive. The positive cases of lesion in the neighborhood of the gyrus fornicatus are very few and far between. As Dr. Dana has spoken of my own case, I might refer to it again, saying that that was one of the cases of superficial, very slight lesion of the central convolution that was followed by a very distinct loss of sensibility. I would like to speak of the case briefly because I encountered it the other day in such a form that if my name had not been connected with it, I should not have known my own case. Brissaud in his recent work alluded to the case as one where the finger penetrated deeply into the cerebrum almost to the capsule.

Dr. CHARLES K. MILLS.—I have at least succeeded in doing one thing, perhaps two; in the first place, in bringing out an interesting discussion; and, in the second place, I believe, a discussion, which, on the whole, confirms the standpoints I have always taken, strange as it may seem to the gentlemen present. It seems to me astounding that Dr. Dana and others speak of physiological or pathological lesion of the motor cortex as exceptionally producing motor symptoms alone. Every one of us must admit the cases referred to by Dr. Starr, Dr. Dana, Dr. Putnam, and Dr. Knapp, because we know they have been well studied and well recorded—cases in which sensory phenomena of some sort have accompanied the motor phenomena in cases of destructive lesion of the pre-Rolandic cortex. We must admit, too, the two or three cases—a miserly number—in which certain experiments upon the cortex in life have caused peculiar temporary disturbances of sensation at the time. It was my purpose not to refer in detail to any cases, but simply to open this discussion. Against these cases of sensory disturbance for strictly limited lesion of the motor cortex, the cases in which symptoms were motor alone instead of sensory are as one hundred to one, and we do not think it longer worth while to collect these cases. I need only refer to my own experience, because it would take too long to bring up statistics. In a score of these cases with the greatest care patients have been examined in life, and the lesions located in death, and in cases of operation the greatest care has been taken in studying sensory phenomena, and those sensory phenomena have not been present. I might mention two cases of my own, one in which Dr. Hearn clearly excised a portion of the cortex right across and in front of the Rolandic fissure; another case in which Dr. Keen did for me the same thing, and in which we studied with the greatest care, as soon as it was possible; the sensory phenomena were not present, but motor phenomena persisted day after day, and day after day changes were noted until the patient was largely restored as regards motion. Others saw the case, and although a large area of the Rolandic cortex had been excised no sensory disturbance resulted. It is not worth while to pit these cases which Dr. Dana has with great skill and labor collected, as an argument of great value against the very numerous cases which teach the other thing. Certainly, however, such cases must be acknowl-

edged. I believe the cases are as stated. Have we no explanation for them? These cases arrange themselves into two or three classes. In the first place a large number of them are temporary; all will admit that, I think. The disturbances, in the second place, are sometimes purely subjective, first admitting the temporary objective disturbances of sensation. Thirdly, they are, as in some of the cases reported by Dr. Dana with great care, sometimes persistent. Charcot before his death suggested one explanation, namely, that these cases are somewhat of the nature of the cases in which we have sensory disturbances in hysterotraumatism. Nothing is wrong about that explanation. Many times we have been told about hemianæsthesia, and about segmental anæsthesia, as the result of a man being struck on the head or leg or trunk, and certainly the traumatism inflicted by the surgeon's knife, or by injury or disease in acute cases is greater than that which we have in other cases. Another explanation is that which I suggested in 1888, which also grows out of these later researches in cortex anatomy. Undoubtedly every area of the cortex, visual, auditory, gustatory—sensory in my sense—must be related and anatomically connected with the motor regions of the cortex, for we have auditory-motor and visual-motor phenomena. It may be that through the destruction of the terminals of the fillet radiations, where they touch the apical processes of the pyramidal cells, or of the cortical field of conjunction between the sensory and motor areas, that temporary disturbances of sensation in some instances result.

I protest against the assertions about positive cases on one side and negative on the other. It is just the other way so far as the record of cases and experiments are concerned. The remarks made by Dr. Starr are, I think, on the whole, confirmatory of what I have stated here. It would seem to me, therefore, Mr. President, that the weight of argument, and the weight of evidence, is still in favor of the localizations to which I have always clung, and which were believed in by Charcot, Ferrier, Bechterew and others. I wish to be understood clearly. Dr. Knapp in closing spoke of the gyrus fornicatus. I have never claimed that the gyrus fornicatus was the sole region of common sensibility in the cortex of the brain. My own position always has been that the sensory cortex proper includes at least a portion of the gyrus fornicatus, quadrate lobule and posterior parietal

convolutions, and the arguments I advance must stand for this region and not for part of it.

Every neurologist knows we have as a hundred to one, for physiological reasons, lesions occurring in the motor region of the brain as against lesions occurring in the sensory region. It is very rare to have a lesion of any sort—tumor, hæmorrhage, or softening or any of the common lesions of the cerebrum—in the gyrus fornicatus, quadrate lobule or the posterior parietal region, as compared with the immense number of lesions in the so-called motor region of the brain, and that is one explanation of the fact that we have so few positive cases to corroborate our views. Another is that probably bilateral destruction is necessary to bring about complete anæsthesia in these cases.

Dr. DANA.—I should like to ask if Dr. Mills will tell us specifically whether he denies that the central convolutions have any sensory function, if he absolutely excludes sensory function from the central convolution.

Dr. MILLS.—I believe what I have said. For practical purposes I believe the central convolution, or at least the convolutions cephalad of the central fissure, have no sensory functions. The posterior central convolution, perhaps, may, with the posterior parietal and the region I have named, take some part in sensory phenomena.

Dr. DANA.—Then I don't think we differ very much.